REMARKS

Claims 131 and 132 have been added to claim the invention with more particularly. No other changes have been made to the claims. Accordingly, Claims 17, 18, 20 - 27, 29 - 31, 38 - 62, 69, 71 - 122, 124, 125, and 127 - 132 are now pending.

Claims 17, 18, 20, 21, 23 - 27, 29, 30, 53, 61, 69, 124, 125, 127, and 128 have been rejected under 35 USC 102(e) as anticipated by Voldman, U.S. Patent 6,455,902 B1. This rejection is respectfully traversed.

Voldman discloses a device arranged in a power clamping configuration for providing protection against electrostatic discharge ("ESD"). In Voldman's ESD protection device, field insulating material is provided along the upper surface of a semiconductor body to define a semiconductor island in which N+ buried region 30 separates overlying P- isolated region 20 from underlying material of P- substrate region 34. The field insulating material consists of deep-trench ("DT") isolation region 28 and the overlying part of surface-adjoining insulator region 14. DT isolation region 28 is formed with polysilicon (also identified by reference symbol "28" in Voldman's specification) covered along its side and lower surfaces with insulator material 13. Substrate region 34 extends below DT isolation region 28.

P+ contact region 16, N+ contact region 24, N+ source region 16, and N+ drain region 22 are provided in the semiconductor island along the upper semiconductor surface of Voldman's ESD protection device. Parts of surface insulator region 14 laterally separate contact regions 16 and 24 from each other and from source/drain regions 16 and 22. A channel portion of P- isolated region 20 laterally separates N+ source/drain regions 16 and 22 from each other. The semiconductor island also includes N+ reach-through region 26 that extends from N+ contact region 24 to N+ buried region 30. Additionally, P+ contact region 36 for P- substrate region 34 lies along the upper semiconductor surface outside the semiconductor island in the implementations of Figs. 1 and 8.

Ronald J. Meetin
Attorney at Law
210 Central Avenue
Mountain View, CA
94043-4869
Tel.: 650-964-9767
Fax: 650-964-9779

Gate structure 12 overlies the channel portion of P- isolated region 20 in Voldman's device. Gate structure 12 appears to consist of a gate electrode (not separately labeled), an underlying gate dielectric layer (also not separately labeled), and dielectric sidewall spacers (likewise not separately labeled) situated along the sides on the gate electrode. The combination of gate structure 12 (specifically the gate electrode and gate dielectric layer),

source/drain regions 16 and 22, and the intervening channel portion of P- isolated region 20 form an insulated-gate field-effect transistor.

A source terminal at source voltage V_S and a drain terminal at drain voltage V_D are respectively connected to source region 16 and drain region 22. A gate terminal at gate voltage V_G is connected to gate structure 12, specifically the gate electrode. P- isolated region 20 is electrically accessed via P+ contact region 16 connected to an isolated region terminal that receives voltage V_{Epi} referred to below as body contact voltage V_{Epi}. N+ buried region 30 is electrically accessed through the combination of N+ reach-through region 26 and N+ contact region 24 connected to a collector terminal that receives collector voltage $V_{collector}$. In the implementations of Figs. 1 and 8, P-substrate region 34 is electrically accessed via P+ contact region 36 connected to a further terminal that receives further voltage V_3.

Independent Claims 17 and 23 are repeated below:

17. A structure comprising:
a varactor which comprises:
(a) a plate region and a body region of a semiconductor body, the body region being of a first conductivity type, the plate region being of a second conductivity type opposite to the first conductivity type, the plate and body regions meeting each other to form a p-n junction and extending to a primary surface of the semiconductor body;
(b) a plate electrode and a body electrode respectively connected to the plate and body regions, the plate electrode being at a plate-to-body bias voltage relative to the body electrode;
(c) a dielectric layer situated over the semiconductor body and contacting the body region; and
(d) a gate electrode situated over the dielectric layer at least where the dielectric layer contacts material of the body region, the gate electrode being at a gate-to-body bias voltage relative to the body electrode, the gate-to-body voltage being maintained approximately constant at a non-zero value as the plate-to-body voltage is varied; and
a field insulating region extending into the semiconductor body along the primary surface to define a semiconductor island laterally surrounded by the field insulating region and substantially fully occupied by material of the plate and body regions.

Ronald J. Meetin
Attorney at Law
210 Central Avenue
Mountain View, CA
94043-4869
Tel.: 650-964-9767
Fax: 650-964-9779

23. A structure comprising:
a varactor which comprises:
(a) a plate region and a body region of a semiconductor body, the body region being of a first conductivity type, the plate region being of a second conductivity type opposite to the first conductivity type, the plate and

body regions meeting each other to form a p-n junction and extending to a primary surface of the semiconductor body;

(b) a plate electrode and a body electrode respectively connected to the plate and body regions, the plate electrode being at a plate-to-body bias voltage relative to the body electrode;

(c) a dielectric layer situated over the semiconductor body and contacting the body region; and

(d) a gate electrode situated over the dielectric layer at least where the dielectric layer contacts material of the body region, the gate electrode being at a gate-to-body bias voltage relative to the body electrode, the gate-to-body voltage differing from the plate-to-body voltage, the gate-to-body voltage varying as a function of the plate-to-body voltage as the plate-to-body voltage is varied during operation of the varactor to cause an inversion layer that meets the plate region to selectively appear and disappear in the body region below the gate electrode; and

a field insulating region extending into the semiconductor body along the primary surface to define a semiconductor island laterally surrounded by the field insulating region and substantially fully occupied by material of the plate and body regions.

On page 2 of the Office Action, the Examiner alleges in connection with Claims 17 and 23 and certain other rejected claims that:

Voldman discloses in figure 1, a structure comprising:

a varactor which comprises:

(a) a plate region 22 and a body region 20 of a semiconductor body, the body region being of a first conductivity type, the plate region being of a second conductivity type opposite to the first conductivity type, the plate and body regions meeting each other to form a p-n junction and extending to a primary surface of the semiconductor body;

(b) a plate electrode VD and a body electrode VEPi respectively connected to the plate and body regions, the plate electrode being at a plate-to-body bias voltage relative to the body electrode;

(c) a dielectric layer, below gate 12, situated over the semiconductor body and contacting the body region; and

(d) a gate electrode 12 situated over the dielectric layer at least where the dielectric layer contacts material of the body region, the gate electrode being at a gate-to-body bias voltage relative to the body electrode; and

a field insulating region 13 extending into the semiconductor body along the primary surface to define a semiconductor island laterally surrounded by the field insulating region and substantially fully occupied by material of the plate and body regions.

Ronald J. Meetin
Attorney at Law
210 Central Avenue
Mountain View, CA
94043-4869
Tel.: 650-964-9767
Fax: 650-964-9779

The Examiner further alleges on page 2 of the Office Action that "Applying and varying voltages to the device is considered a method of using the device".

As a preliminary matter, each of Claims 17 and 23 recites that the field insulating region extends "along the primary surface" of the semiconductor body. Insulating material 13 seemingly analogized by the Examiner to the field insulating region of Claims 17 and 23 does not reach the upper semiconductor surface of Voldman's ESD protection device. Likewise, DT isolation region 28 does not reach the upper semiconductor surface of Voldman's ESD protection device. As a result, neither insulator material 13 nor DT isolation region 28 meets the requirement of Claims 17 and 23 that the field insulating region extend along the semiconductor body's primary surface.

Applicant's Attorney notes that the combination of DT isolation region 28, including insulator material 13, and the overlying part of insulator region 14 reaches the upper semiconductor surface of Voldman's device. Accordingly, Applicant's Attorney will present the remainder of these remarks under the assumption that the combination of DT isolation region 28 and the overlying part of insulator region 14 is viewed as analogous to the field insulating region of Claims 17 and 23.

With the foregoing in mind, each of Claims 17 and 23 is directed to a structure in which a field insulating region laterally surrounds parts of a varactor, i.e., a variable capacitor. Voldman teaches an ESD protection device having a field insulating region, not a variable capacitor having a field insulating region. Applicant's Attorney does not see any reasonable way in which Voldman's ESD protection device could function as a variable capacitor whose capacitance can be placed in a signal path and controllably adjusted. Despite having a field insulating region, Voldman is totally off point as to the varactor portion of the structure covered by each of Claims 17 and 23.

More specifically, Claims 17 and 23 each require that the semiconductor island defined by the field insulating region be "substantially fully occupied by material of the plate and body regions" of the recited varactor.

Ronald J. Meetin
Attorney at Law
210 Central Avenue
Mountain View, CA
94043-4869
Tel.: 650-964-9767
Fax: 650-964-9779

N+ contact region 24 and N+ reach-through region 26 of Voldman's ESD protection device <u>lie</u> in the semiconductor island laterally bounded by the field insulating region formed with DT isolation region 28 and the overlying part of insulator region 14. As is clear from Fig. 1 (or any of Figs. 4, 6, and 8) of Voldman, N+ regions 24 and 26 <u>occupy</u> a <u>substantial part</u> of that semiconductor island. Voldman therefore does <u>not</u> meet the requirement of Claims 17 and 23 that the semiconductor island defined by the field insulating region be

substantially fully occupied by material of the plate and body regions[1]. Accordingly, Voldman does not anticipate Claim 17 or 23.

N+ contact region 24 and N+ reach-through region 26 are essential parts of Voldman's ESD protection device. In particular, Voldman needs N+ regions 24 and 26 for electrically accessing N+ buried region 30 in order for the ESD protection device to operate properly. Nothing in Voldman would provide a person skilled in the art with any reason for deleting, or making it obvious to delete, N+ regions 24 and 26 from Voldman's device. Consequently, Claims 17 and 23 are patentable over Voldman.

Furthermore, source region 18 of Voldman's ESD protection device lies in the semiconductor island bounded by the field insulating region formed with DT isolation region 28 and the overlying part of insulator region 14. As is likewise clear from Fig. 1 (or any of Figs. 4, 6, and 8) of Voldman, source region 18 occupies a substantial part of that semiconductor island. The presence of source region 18 also prevents Voldman from meeting the requirement of Claims 17 and 23 that the semiconductor island defined by the field insulating region be substantially fully occupied by material of the plate and body regions[2].

Voldman's device needs source region 18 for the device to operate properly. There would be no reason for deleting source region 18. The distinction resulting from the

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[1] To the extent that the Examiner may have actually intended to analogize only insulator material 13 (or DT isolation region 28) to the field insulating region of Claims 17 and 23 and thus to the extent that the portion of insulator region 14 overlying insulator material 13 (or DT isolation region 28) might not be considered part of the field insulating material analogized to the field insulating region of Claims 17 and 23, N+ reach-through region 26 lies in the region of semiconductor material bounded by insulator material 13 (or DT isolation region 28) and clearly occupies a substantial part of that semiconductor region. If the portion of insulator region 14 overlying insulator material 13 (or DT isolation region 28) were not considered part of the field insulating material analogized to the field insulating region of Claims 17 and 23, Voldman would still fail to meet the requirement of Claims 17 and 23 that the semiconductor island defined by the field insulating region be substantially fully occupied by material of the plate and body regions. For the reasons presented above, Voldman would also fail to meet the requirement of Claims 17 and 23 that the field insulating region extend along the semiconductor body's primary surface.

[2] If the Examiner actually intended to analogize only insulator material 13 (or DT isolation region 28) to the field insulating region of Claims 17 and 23 and thus does not consider the portion of insulator region 14 overlying insulator material 13 (or DT isolation region 28) to be part of the field insulating region analogized to the field insulating region of Claims 17 and 23, Voldman would again fail to meet the requirement of Claims 17 and 23 that the field insulating region extend along the primary surface of the semiconductor body. Regardless of how the regions of Voldman's device are analogized to the elements of Claims 17 and 23, Voldman thus cannot simultaneously meet both the claim requirement that the semiconductor island defined by the field

Ronald J. Meetin
Attorney at Law
210 Central Avenue
Mountain View, CA
94043-4869
Tel.: 650-964-9767
Fax: 650-964-9779

presence of source region 18 in Voldman's device is an additional reason why Claims 17 and 23 are patentable over Voldman.

Claims 18, 20, 21, 53, 69, 124, and 125 all depend (directly or indirectly) from Claim 17. The same applies to new Claim 131. Claims 24 - 27, 29, 30, 61, 127, and 128, along with new Claim 132, all depend (directly or indirectly) from Claim 23. Consequently, dependent Claims 18, 20, 21, 24 - 27, 29, 30, 53, 61, 69, 124, 125, 127, 128, 131, and 132 are patentable over Voldman for the same reasons as Claims 17 and 23.

Additionally, Claim 18, which depends from Claim 17, recites that the claimed structure further includes "componentry for maintaining the gate-to-body voltage approximately constant at the non-zero value".

The Examiner has not indicated how Voldman's ESD protection device is believed to meet the further limitation of Claim 18. In regard to the Examiner's allegation that "Applying and varying voltages to the device is considered a method of using the device", Claim 18 specifies that the claimed structure includes <u>componentry</u> for performing the recited voltage function. To the extent that it might be proper to give no weight to the recitation in Claim 17 that the gate-to-body voltage is maintained approximately constant at a non-zero value (as the plate-to-body voltage is varied) because that recitation is a method limitation, the further recitation in Claim 18 that the claimed structure includes componentry for performing this voltage function adds <u>physical structure</u> to the structure claimed in Claim 18 and must be given weight in examining Claim 18.

Voldman uses reference symbol "V_{body}" to represent the voltage of P- isolated region 20 analogized by the Examiner to the body region of the rejected claims. Using the Examiner's analogies, the "gate-to-body" voltage of Voldman's ESD protection device is the difference V_G - V_{body} between gate voltage V_G applied to the gate terminal and body voltage V_{body} of isolated region 20. In col. 3, Voldman discloses that body voltage V_{body} may be the same as, or differ from, body contact voltage V_{Epi} applied to the isolated region terminal connected to P+ contact region 16 for isolated region 20[3].

Ronald J. Meetin
Attorney at Law
210 Central Avenue
Mountain View, CA
94043-4869
Tel.: 650-964-9767
Fax: 650-964-9779

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insulating region be substantially fully occupied by material of the plate and body regions and the claim requirement that the field insulating region extend along the semiconductor body's primary surface.

[3] Current flowing through P- isolated region 20 always encounters some parasitic body resistance. By specifying that that body voltage V_{body} may be the same as, or differ from, body contact voltage V_{Epi}, Voldman presumably means (a) that the parasitic body resistance can be ignored in some situations, e.g., because it is

Fig. 4 of Voldman illustrates an implementation of Voldman's ESD protection device in which the gate terminal is directly connected to the isolated region terminal. Gate voltage V_G thereby equals body contact voltage V_{Epi} in this implementation. For the situation in which body voltage V_{body} is the same as body contact voltage V_{Epi}, body voltage V_{body} equals gate voltage V_G so that gate-to-body voltage $V_G - V_{body}$ of Voldman's device implementation in Fig. 4 is zero. In this situation, Voldman's device implementation in Fig. 4 does not meet the requirement of Claim 18 that the gate-to-body voltage be <u>non-zero</u>.

Fig. 6 of Voldman illustrates the situation in which body voltage V_{body} differs from body contact voltage V_{Epi} due to parasitic body resistance R_{Epi}. Body voltage V_{body} then depends on body contact voltage V_{Epi} and on avalanche current I_A through body resistance R_{Epi} according to the equation given in col. 5 of Voldman. Upon applying this teaching to the device implementation shown in Fig. 4 of Voldman where gate voltage V_G equals body contact voltage V_{Epi}, gate-to-body voltage $V_G - V_{body}$ of Voldman's device implementation in Fig. 4 appears to equal I_AR_{Epi} for the situation in which body voltage V_{body} differs from body contact voltage V_{Epi}.

Avalanche current I_A varies significantly with time. In the situation where body voltage V_{body} differs from body contact voltage V_{Epi}, gate-to-body voltage $V_G - V_{body}$ of Voldman's device implementation in Fig. 4 does not meet the requirement of Claim 18 that the gate-to-body voltage be approximately <u>constant</u>. The net result is that the implementation of Voldman's device in Fig. 4 does not meet the further limitation of Claim 18 regardless of whether body voltage V_{body} equals, or differs from, body contact voltage V_{Epi}.

As far as Applicant's Attorney can determine, no other part of Voldman discloses or suggests the further limitation of Claim 18. A separate basis is thereby provided for allowing Claim 18 over Voldman.

Claim 26, which depends from Claim 23, recites that the claimed structure further includes "componentry for causing the gate-to-body voltage to vary as a function of the plate-to-body voltage". This componentry implements the requirements of Claim 23 that the gate-to-body voltage differ from the plate-to-body voltage and that the gate-to-body voltage vary as a function of the plate-to-body voltage as the plate-to-body voltage is varied during

Ronald J. Meetin
Attorney at Law
210 Central Avenue
Mountain View, CA
94043-4869
Tel.: 650-964-9767
Fax: 650-964-9779

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quite small, so that that body voltage V_{body} equals body contact voltage V_{Epi} and (b) that the parasitic body resistance must be accounted for in other situations so that that body voltage V_{body} differs from body contact voltage V_{Epi}.

varactor operation to cause the recited inversion layer to selectively appear and disappear. Claim 27, which depends from Claim 26, further recites that "the componentry causes the gate-to-body voltage to vary approximately linearly with the plate-to-body voltage".

In regard to Claims 26 and 27, the Examiner alleges on page 3 of the Office Action that "see figure 4 and column 4 [of Voldman], wherein the gate voltage corresponds with drain current, hence drain voltage, approximately linearly"[4].

As mentioned above, Fig. 4 of Voldman depicts an implementation of Voldman's device in which the gate terminal is directly connected to the isolated region terminal so that gate voltage V_G equals body contact voltage V_{Epi}. Using the Examiner's analogies, the "gate-to-body" voltage of Voldman's device in Fig. 4 is again the difference V_G - V_{body}. The "plate-to-body" voltage of Voldman's device in Fig. 4 is then the difference V_D - V_{body} between drain voltage V_D applied to the drain terminal of N+ drain region 22 and body voltage V_{body} of P- isolated region 20.

As also mentioned above, body voltage V_{body} may be the same as, or differ from, body contact voltage V_{Epi}. Gate-to-body voltage V_G - V_{body} of Voldman's device implementation in Fig. 4 is then zero or varies. However, regardless of whether gate-to-body voltage V_G - V_{body} is zero or varies, nowhere does Voldman disclose that voltages V_G, V_{body}, and V_D are related to one another in such a way that gate-to-body voltage V_G - V_{body} for the device implementation of Fig. 4, or for any of Voldman's other device implementations, varies as a function of plate-to-body voltage V_D - V_{body} as plate-to-body voltage V_D - V_{body} is varied during device operation. Voldman thus does not disclose the further limitation of Claim 26 that the claimed structure include "componentry for causing the gate-to-body voltage to vary as a function of the plate-to-body voltage" subject to the requirements of Claim 23 that the gate-to-body voltage differ from the plate-to-body voltage and that the gate-to-body voltage vary as a function of the plate-to-body voltage as the plate-to-body

Ronald J. Meetin
Attorney at Law
210 Central Avenue
Mountain View, CA
94043-4869
Tel.: 650-964-9767
Fax: 650-964-9779

4 Applicant's Attorney does not understand this allegation. Taking note of the fact that "drain current" for a field-effect transistor normally means the current flowing between the transistor's source and drain regions via the intervening channel region, the only current referred to in col. 4 of Voldman is current "I_A" recited parenthetically near the middle of the column. Col. 5 of Voldman indicates that current "I_A" is the avalanche current flowing through resistance R_{Epi}. As shown in Fig. 6 of Voldman, resistance R_{Epi} is the parasitic body resistance from P+ contact region 16 through P- isolated region 20 to N+ drain region 22. As a result, avalanche current I_A appears to be the current flowing between contact region 16 and drain region 22 via

voltage is varied. Consequently, Claim 26 and its dependent Claim 27 are separately patentable over Voldman.

Also, the Examiner's allegation that "see figure 4 and column 4 [of Voldman], wherein the gate voltage corresponds with drain current, hence drain voltage, approximately linearly" bears no evident relation to the further limitation of Claim 27 that "the componentry causes the gate-to-body voltage to vary approximately linearly with the plate-to-body voltage". An additional basis is thereby provided for separately allowing Claim 27 over Voldman.

Claims 125 and 128, which respectively depend from Claims 17 and 23, each recite that "the field insulating region substantially laterally surrounds at least one further semiconductor island occupied by material of the body region substantially up to the primary surface such that material of the body region extends continuously from each semiconductor island to each other semiconductor island".

With respect to Claims 125 and 128, the Examiner alleges on page 3 of the Office Action that "field insulating region 14 substantially laterally surrounds at least one further island occupied by material of the body region substantially up to the primary surface such that material of the body region extends from each semiconductor island to each other semiconductor island".

Voldman discloses that P- substrate region 34 extends (downward) around the field insulating region formed by DT isolation region 28 (including insulator material 13) and the overlying part of insulator region 14. See col. 3 and Fig. 1 of Voldman. However, the combination of N+ buried region 30, DT isolation region 28, and the overlying part of insulator region 14 separates (isolates) isolated region 20 from substrate region 34. As a result, isolated region 20 analogized by the Examiner to the body region of the rejected claims does not extend around the field insulating region formed by DT isolation region 28 and the overlying part of insulator region 14. Voldman thus does not disclose the further limitation of Claims 125 and 128 that the field insulating region substantially laterally surround "at least one further semiconductor island occupied by material of the body region substantially up to the primary surface such that material of the body region extends

Ronald J. Meetin
Attorney at Law
210 Central Avenue
Mountain View, CA
94043-4869
Tel.: 650-964-9767
Fax: 650-964-9779

isolated region 20 rather than the "drain current" flowing between source region 18 and drain region 22 via the intervening channel portion of isolated region 20.

continuously from each semiconductor island to each other semiconductor island". Claims 125 and 128 are separately patentable over Voldman.

New Claims 131 and 132, which respectively depend from Claims 17 and 23, each recite that "the body region extends deeper below the primary surface than does the field insulating region".

Both DT isolation region 28 and insulator material 13 in Voldman extend deeper below the upper semiconductor surface than does P- isolated region 20 analogized by the Examiner to the body region of the rejected claims. As a result, Voldman does not disclose the requirement of each of Claims 131 and 132 that the body region extend deeper below the primary surface than the field insulating region. A separate basis is thereby provided for allowing Claims 131 and 132 over Voldman.

Claims 22, 31, 54, and 62 have been rejected under 35 USC 103(a) as obvious based on Voldman in view of Misu et al., Japanese Patent Publication 7-226643. This rejection is respectfully traversed.

Misu[5] discloses an elastic wave element in which parallel fingers 2 of one electrode are interdigitated with parallel fingers 2 of another electrode. The widths of, and spacings between, electrode fingers 2 vary and typically increase (or decrease) in a direction perpendicular to the lengths of fingers 2.

Claims 22 and 54 both depend (indirectly) from Claim 17. Claims 31 and 62 both depend (indirectly) from Claim 23. Nothing in Misu would cause either of Claims 17 and 23 to be unpatentable based on Voldman in view of Misu. Consequently, dependent Claims 22, 31, 54, and 62 are patentable over Voldman and Misu for the same reasons that Claims 17 and 23 are patentable over Voldman.

Ronald J. Meetin
Attorney at Law
210 Central Avenue
Mountain View, CA
94043-4869
Tel.: 650-964-9767
Fax: 650-964-9779

[5] In correction of a page citation error made in the Amendment submitted 14 January 2004, the reference on page 25 of that amendment in connection with Misu to page "27" of the Response submitted 17 June 2003 should have been to page "14" of the 17 June 2003 Response. Similarly, the Misu references on page 29 of the Amendment submitted 21 July 2004 to page "27" of the 17 June 2003 Response and to page "30" of the 14 January 2004 Amendment should respectively have been to page "14" of the 17 June 2003 Response and to page "25" of the 14 January 2004 Amendment.

Claims 22 and 31 each recite that "the plate region comprises a main plate portion and at least one finger portion continuous with the main plate portion, extending laterally away from the main plate portion, and meeting the body region therealong".

With regard to Claims 22 and 31, the Examiner first alleges on page 4 of the Office Action that "Voldman discloses the claimed invention, as discussed above, except for the plate region having finger portions continuous with the main plate portion, extending laterally away from the main plate portion and meeting the body region there along". The Examiner then alleges that Misu "discloses in figures 7, 9, and 12, that unparallel conductive finger shaped contact regions in a device are interdigitized [sic, interdigitated]" and that it therefore "would have been obvious to one of ordinary skill in the art at the time of the invention to make the finger shaped plate portions of the Voldman structure finger shaped, since this kind of configuration reduces the current density in a region of a contact area and consequently reduces undesirable effects such as heat concentration in the contact region".

The finger portions in each of Claims 22 and 31 are parts of the plate region and thus consist substantially of <u>doped semiconductor material</u>. In contrast, fingers 2 of Misu are electrode fingers and thus presumably consist largely of <u>metal</u>. Hence, the finger portions in each of Claims 22 and 31 are constituted quite differently than Misu's fingers. Even if it were reasonable to combine Voldman and Misu, the combination would not teach the finger portions of Claims 22 and 31. This is a separate reason why Claims 22 and 31 are patentable over Voldman and Misu. The same applies to Claims 54 and 62, because they respectively depend from Claims 22 and 31.

Claims 47 - 52 and 55 - 60 have been indicated as allowable if rewritten in independent form.

Claims 47 - 52 all depend (directly or indirectly) from Claim 17. Claims 55 - 60 all depend (directly or indirectly) from Claim 23. Inasmuch as Claims 17 and 23 have been shown to be patentable over the applied art, dependent Claims 47 - 52 and 55 - 60 are allowable in their present form.

Ronald J. Meetin
Attorney at Law
210 Central Avenue
Mountain View, CA
94043-4869
Tel.: 650-964-9767
Fax: 650-964-9779

The allowance of Claims 38 - 46, 71 - 122, 129, and 130 is noted.

In short, Claims 17, 18, 20 - 27, 29 - 31, 53, 54, 61, 62, 69, 124, 125, 127, 128, 131, and 132 have been shown to be patentable over the applied art. Claims 47 - 52 and 55 - 60 are allowable in their current form. Accordingly, Claims 17, 18, 20 - 27, 29 - 31, 47 - 62, 69,

124, 125, 127, 128, 131, and 132 should be allowed along with Claims 38 - 46, 71 - 122, 129, and 130 so that the application may proceed to issue.

Please telephone Attorney for Applicant at 650-964-9767 if there are any questions.

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Respectfully submitted,

Ronald J. Meetin

Ronald J. Meetin
Attorney for Applicant(s)
Reg. No. 29,089

210 Central Avenue
Mountain View, CA 94043-4869

Ronald J. Meetin
Attorney at Law
210 Central Avenue
Mountain View, CA
94043-4869
Tel.: 650-964-9767
Fax: 650-964-9779